An Intelligent Inspection and Survey Robot

John M. Holland
Cybermotion, Inc.
719 Gainsboro Road
Roanoke, VA 24016

Abstract

The Autonomous Robotic Inspection Experimental System (ARIES) project is under development for the U.S. Department of Energy (DOE) to survey and inspect drums containing low-level radioactive waste stored in warehouses at DOE facilities. The drums are typically stacked three to five high and arranged in rows with three-foot aisle widths. A mobil robot will navigate through the aisles and perform visual inspection, typically performed by a human inspector, making decisions about the condition of the drums and maintaining a database of pertinent information about each drum. The first phase of this three-phase project was a task-oriented, proof-of-principle phase in which demonstrations and reports were provided as the deliverables. The second phase was a technology integration effort to develop a single, commercializable prototype mobile robot capable of meeting many of the demands of the mission of environmental compliance and clean-up of DOE sites. During the current Phase 3, ARIES has been evaluated and demonstrated at Fernald's TS-4 drum storage facility and has undergone safety and human factors assessment by the International Union of Operating Engineers (IUOE) in Beaver, WV. The final phase focused on productizing the system for commercial availability. Two systems will be delivered to DOE sites for early user evaluation. The first system will be installed at Los Almos National Laboratories in November 1997 and the other at the Idaho National Engineering laboratory in the spring of 1998.

As a research and development industrial partner on the project team and in cooperation with researchers at the University of South Carolina and Clemson University, Cybermotion, Inc. developed a "narrow aisle" version of their Navymaster series of mobile robots to serve as the base platform for ARIES. This new version (Model K3A) consisted of an improved and enhanced mobile platform and a new turret that enables the vehicle to turn around in a 36 inch wide aisle. Cybermotion enhanced the robots sonar system and improved its ability to navigate in drum aisles and other close areas. Also, a light detecting and ranging (LIDAR) system was added to enhance navigation in the large open areas common to the warehouses.

The University of South Carolina (USC) integrated an onboard computer system for real-time management of the system. The onboard computer evolved from a VME platform in Phase 2 to a Pentium PC platform using the NT operating system in Phase 3. USC also developed sophisticated software for mission management, communications and a graphical user interface. A graphical offboard supervisory workstation is used for high-level planning, control, monitoring and reporting.

A camera positioning system (CPS) was designed and fabricated as a joint effort between the University of South Carolina and Cybermotion. The CPS automatically positions an inspection module as required for drum inspection under program control. The inspection module consists of special video cameras, strobes, lasers and bar-code readers. The Phase 3 system uses a single inspection module positioned by a fixed length linear actuator and a four-bar linkage under vehicle computer control. A telescoping positioning system was also developed under this program.

Clemson University developed a video imaging and computer vision system to gather and analyze the drum data. This system locates and identifies each drum, locates abnormal features on the surface of the drum (such as dents, blisters, streaks and rusted areas), and updates the database containing the inspection information. Color processing, using specialized algorithms, incorporates supplemental multi-strobe lighting and differential structured light during the image capture. An adaptive algorithm and learning concept, requiring little effort by unskilled operators are used to "train" the vision system prior to the inspection process.

The objective of this project is to develop a commercially available robotic system for drum inspection that will be available to all DOE sites requiring drum inspection.

Acknowledgments

This work was funded by the U.S. Department of Energy's Federal Energy Technology Center, Contact METCDE-AC21-92MC29115, via task order under South Carolina Universities Research and Educational Foundation (SCUREF). Period of performance: 30 September 1992 - 31 December 1997. FETC Contracting Office Representative: Cliff Carpenter. ARIES is a collaborative effort between SCUFEF, Clemson University (CU), University of South Carolina (USC), and Cybermotion, Inc. Current team members include: SCUREF - Ed Hamilton, Angela Harrington; USC - Dr. Robert Pettus, Paul McCarty; CU - Dr. Robert Schalkoff; Cybermotion - John Holland, Ken Kennedy, Al Mew, Michael Lee, David Fisher, Robert Peerman.